U. S. DEPARTMENT OF AGRICULTURE,
FOREST SERVICE.
HENRY S. GRAVES, Forester.

THE NATIONAL FOREST MANUAL.

INSTRUCTIONS TO FOREST OFFICERS RELATING TO FOREST PLANS, FOREST EXTENSION, FOREST INVESTIGATIONS, LIBRARIES, COOPERATION, AND DENDROLOGY.

ISSUED BY THE
SECRETARY OF AGRICULTURE,
TO TAKE EFFECT
NOVEMBER 1, 1911.

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INSTRUCTIONS TO FOREST OFFICERS.

UNITED STATES DEPARTMENT OF AGRICULTURE,
FOREST SERVICE,
Washington, October 14, 1911.

The following procedure and instructions relating to forest plans forest extension, forest investigations, libraries, cooperation with other Departments of the Federal Government and with States and private owners, and dendrology, are hereby established and issued to take effect November 1, 1911.

H. S. GRAVES,
Forester.

Approved:
JAMES WILSON,
Secretary.

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THE NATIONAL FOREST MANUAL.

FOREST PLANS.

Object.

The object of the Forest plan is to systematize and control the management of each Forest upon a definite basis which shall represent the cumulative experience and information which the Service has acquired.

Kinds of plans.

Three different kinds of plans, differing only in scope and intensity, will be used in developing the management of the respective Forests, namely: Preliminary plans, working plans, and annual plans.

Preliminary plan.

A preliminary plan is simply a systematic statement, prepared from the best information now available, of the resources of the Forest, the conditions governing their use and development, and the administrative measures to be followed in their management.

Working plan.

A working plan is a similar statement, more complete and final in character, based upon thorough investigation and accurate data, and including a definite scheme of management devised for a period of years.

Annual plan.

The annual plan is covered by the various periodic estimates and reports called for by the administrative sections of the Manual. It constitutes a periodic revision of the preliminary or working plan, together with the specific application of these plans to the business of the Forest for the ensuing year.

Ground to be covered.

The subjects to be covered in all forest plans are:

1. General administration.
2. Silvicultural management.
3. Grazing management.
4. Permanent improvements.
5. Forest protection.
6. Uses of Forest land, including settlements, special uses, water power, and administrative sites.

Coordination of work.

The forest plan should coordinate the various lines of work in each unit. It should provide for the most efficient administration and the best use of the Forest resources possible at the least practicable cost.

Area covered by plan.

Each forest plan will provide for the management of a whole administrative unit or Forest. No plan should include more than one Forest. Where conditions in adjacent Forests are similar, or the Forests supply the same markets, these facts will be considered, particularly in the location of cutting areas and limitation of the annual cut. Such considerations will also be necessary in grazing and protection.

Division of Forest.

Where necessary, because of important market or topographic considerations, the Forest may be divided into areas each of which will be managed with the idea of sustained yield. If necessary to assist in regulating the cut, a subdivision of the above areas may be made; this should be on the basis of logging units or groups of logging units, the boundaries depending entirely upon topography. Unnecessary divisions will not be made, since they complicate administration. Where possible the lines of administrative subdivisions and those for the technical management of the Forest will be coordinated.

Maps.

Maps should follow the Atlas legends as far as practicable. They will be prepared as indicated in the instructions for each part of the plan and in addition where necessary to make the plan clear or where their use makes it possible to reduce description.

Responsibility for plans.

Final responsibility in the preparation of all forest plans rests with the supervisor. He should, in submitting the plan for approval, transmit any recommendations of the officer in direct charge of its preparation which differ materially from the plan as submitted.

Improvement of plans.

Since the completion of any plan is but the beginning of systematic management, every effort should be made by the local force, with or without assistance from the district forester, to improve plans which have been prepared and to obtain the additional data needed for more efficient administration.

Filing.

Copies of all preliminary or working plan data, except maps, will be filed in separate folders, or, if this is not feasible, cross references will be inserted.

PRELIMINARY PLANS.

A preliminary plan should be prepared as soon as practicable on each Forest from the data now available. The compilation of such data in the form of a definite plan of management will systematize and strengthen the administration of the Forest and furnish a basis for further extension and improvement. The following points should be covered:

Under "General administration" should be given:

General administration.

1. The Forest force, based upon the men required to transact economically the business of the Forest and furnish adequate protection during the fire season.

2. Division of the Forest into administrative and patrol districts to be shown on a map.

3. A record by classes of past receipts and expenditures and an estimate of future receipts and expenditures.

Under "Silvicultural management" should be given:

Silvicultural management.

1. Divisions and subdivisions, if any, with reasons.

2. Approximate estimates of timber by convenient, technical, administrative, or legal subdivisions.

3. The silvicultural systems which should be used, by types, and by divisions if modification of the system on different divisions is necessary. Principles to govern marking drawn from the best silvical data available. The object of management for the Forest, as

far as available information makes it possible, or for divisions, classes of material to be produced, species to be favored, and rotation desirable.

4. A rough classification of the timber on the Forest, or parts of the Forest, in accordance with its age and condition, showing the bodies of mature timber, of thrifty timber not yet in need of cutting, and of young growth; together with a plan of cutting, showing the order in which the various areas should be logged. Areas of protection forest where no cutting is recommended should be indicated. The approximate periods in which immature stands will reach merchantable size should be shown.

5. Recommended limitations on the annual cut for the ensuing four or five years.

6. Data on methods of logging, accessibility of merchantable bodies of timber, costs of logging and manufacture, markets and market conditions, demand, prices, etc.

7. The policy for the whole Forest, or divisions if advisable, which should be followed as to sales, reservations for local industries, and free use, together with the opportunities for desirable sales.

8. Tentative stumpage rates for the entire Forest, or divisions.

9. Improvements needed to facilitate the sale or protection of timber. To be incorporated in the permanent improvement plan.

10. The approximate areas on which artificial reforestation will be necessary in whole or in part, together with the species to be used, and, broadly, the plan to be followed during the ensuing four or five years, plans for nurseries, outline of desirable experiments, etc.

11. The order in which the various parts of the Forest should be covered by complete reconnaissance; desirable silvical studies leading toward better management, etc.

Map for silvicultural plan.

This part of the plan should be accompanied by a map showing topography in as much detail as data available will allow, roads, trails, forest types, age classes, if necessary, nursery sites, and areas proposed for artificial regeneration. Much of the other data called for may be shown either on the map or in concise tabulations with explanatory notes.

Grazing.

Under "Grazing" the essential point is to compile all available information on the range conditions in the Forest as a basis for systematic range protection, development, and improvement. The following outline should be followed in so far as the data are now available, or can be obtained by the supervisor. It is intended only as a guide and should be varied where necessary to cover local conditions. More detailed outlines may be prepared where advisable. All the data collected should contribute directly to the management of the grazing business on the Forest.

1. Classification of grazing lands and estimates of carrying capacity, including:

Classification and estimates.

(1) Determination of characteristic ecological types or groups of forage plants each of which includes certain combinations of grasses, weeds, and browse. The types should be mapped on a base map of the Forest. Groups containing poisonous plants may demand particular attention.

(2) Concise descriptions of each group or type including notes on individual species, the seasons when the plants may be used, the relative grazing value of the types, and the class of stock for which they are best suited.

(3) A record in tabulated form of the kind and amount of stock per section at present grazed on the land, with an estimate of its present grazing capacity, and if overgrazed or poorly stocked with forage plants the capacity to which it may be brought by proper treatment.

Range improvements.

2. Range improvements: Map record of present and needed watering facilities, including wells, streams, springs, natural and artificial ponds and tanks, drift fences, and other improvements necessary for the best use of the range. To be incorporated in the permanent improvement plan.

Herbarium.

3. Herbarium: A collection in duplicate of the principal forage plants on the Forest, including grasses, weeds, and brush, to be kept in the supervisor's office for reference.

Plan of management.

4. The plan of management should include, with necessary maps, notes, and explanatory data, provision for:

(1) The control and eradication of poisonous plants.

(2) Improvement of overgrazed or poorly stocked areas, including reseeding, the use of a rotation scheme of excluding stock from areas for a part of the year to allow seeding of native plants, etc.

(3) Fuller use of the range by the class of stock for which it is best suited, including areas not now used.

(4) Exclusion or reduction of stock or the change of grazing seasons when necessary for silvical reasons or the protection of watersheds for irrigation or municipal water supply. Reduction to prevent overgrazing, or erosion caused by grazing.

(5) The better handling of stock, including salting, bedding, the prevention of concentration to the injury of the range, improved herding methods, etc.

(6) Improvement in range districts, range allotments, etc.

(7) The extermination of predatory animals, based upon the kind and amount of damage done.

(8) The extermination of prairie dogs, based upon the area occupied and the damage done.

Permanent improvements.

A systematic plan for the permanent improvements on the Forest should be steadily developed, extended, and improved. It will include all classes of permanent improvements necessary for the protection, development, and administration of the Forest, the need of which can be clearly foreseen.

Improvement map.

The improvement plan will take the form of a map, and such additional notes as may be necessary for its proper understanding. Rough estimates of cost should be included wherever obtainable. Before survey, roads, trails, etc., will be located approximately on the map. Corrections and additions to the improvement plan will be made whenever the need is apparent. The following kinds of work will be considered: Roads, trails, bridges, telephone lines, signal systems, permanent and temporary headquarters, pastures, lookout towers, fire lines, tool boxes, improvements necessary for range development or making timber accessible, and areas in which the blazing and posting of trails is urgent.

Forest protection.

Under "Forest protection" provision will be made for protection against fire and insects, and the protection of nurseries and plantations against rodents.

A plan for fire protection, as complete as is now practicable, should be formulated and put into effect on each Forest. Special attention should be given to the extension and modification of this plan as further experience is acquired.

Fire plan.

The fire plan will consist of a map showing detailed topography, forest types, all permanent improvements which will be of any value in fire protection, lookout points, lines of fire patrol, camping sites, places where assistance in fighting fire may be obtained, areas of particular menace and areas in particular need of protection, and detailed directions to rangers concerning fire patrol, and cooperation with other districts and forests. Directions for preparing fire plans are given under "Fire protection" in the miscellaneous section of the Manual.

Special outlines for other protective features of the forest plan may be prepared for the respective Forests in accordance with individual needs.

Other protective features.

Under "Uses of Forest land" data should be collected showing:

1. Sale prices of agricultural lands within or near the Forest, including stump lands, unimproved nontimbered lands, and improved ranches.

Uses of Forest land. Settlement.

2. Cost of clearing and stumping timbered lands.

3. Comparative value of timbered land for agricultural and forest purposes.

4. Any other data which will aid in formulating a settlement policy for the Forest.

The location of all uses, including Interior Department rights of way, which have been granted should be recorded on a base map of the Forest. Any information secured as to tracts desirable for particular uses should be similarly recorded, especially reservoir and dam sites, as part of the inventory of the resources of the Forest. Data on the value of uses to the permittee should be collected and recorded with the forest plan as a basis for the regulation of charges.

Special uses.

Special investigations of the power possibilities of the Forests, including stream measurements in cooperation with the Geological Survey and the collection of cost and market data will be conducted under the direction of the district forester in cooperation with the supervisors.

Water power.

All administrative sites designated as "selected" or "proposed" should be shown on the improvement map of the Forest, together with data indicating the use to be made of each site and the extent to which it has been improved. Sufficient additional data will be recorded to show in concrete form the system of administrative sites devised for the forest, including patrol and lookout stations, nurseries, and sites required for logging facilities and other uses in connection with the sale of timber.

Administrative sites.

WORKING PLANS.

A working plan is simply an extension and development of the preliminary plan, based upon more exact data. Such a plan should ultimately be prepared for every Forest as the need for a more systematic basis of management becomes urgent. Reconnaissance work should, except in unusual cases, result in working plans.

For what Forests first prepared.

Working plans will be prepared first on Forests where the demand for timber is great as compared with the supply, and where large quantities of timber are evidently mature and it is reasonably certain that sales can be made if the proper data are secured. It may be advisable to prepare special working plans for Forests on which large areas are in need of reforestation. Special grazing working plans may be prepared for Forests where the use of forage resources is of importance. Special problems in any other phase of Service work demanding careful study may require the preparation of working plans. Where conditions on a Forest differ widely, it may be advisable to cover only the part of a Forest to which the special administrative urgency applies.

Period of plan.

Each working plan will outline the general management of the Forest for a long period, usually a rotation in the recommendations on timber cuttings, and the management in detail for some such period as 10 or 15 years.

Detail in plan.

The amount of detail in the working plan will depend upon the value of the forest products concerned, the need for intensive methods, and the certainty or possibility of large returns within the probable life of the plan. On Forests or parts of Forests where the demand for timber equals or exceeds the amount which can be cut with safety, the plan for silvicultural management must be in much greater detail than where the demand is comparatively small. The requirements of detail in the different parts of the plan and in different working units must be adjusted to the administrative needs of the Forest in all lines of work.

Working plan conference.

When it has been decided to make a working plan, its essential features and the field work necessary should be outlined at a conference between the officer who will have charge of the field work, the supervisor of the Forest, the assistant district foresters concerned, and the district forester at his discretion. It is particularly necessary that the general system or systems of management be determined, and the methods for determining the yield of each unit be decided upon. Plans may then be made to secure the exact data needed and unnecessary work eliminated. Slight modifications which do not necessitate reprinting will, when necessary, be made in standard forms for these purposes. The preliminary plan for the Forest and working plans already prepared will form the basis for this discussion.

Method of obtaining data.

Field data will in general be obtained by special parties, which as far as possible should consist of experienced men. Under this system the results will be more accurate and uniform, and there will be less interruption to the regular Forest work and more rapid improvement in methods and results. As far as possible, the data for all parts of the plan will be collected at the same time, if necessary by specialists temporarily assigned to the party. The data for planting or grazing features may be collected independently when the need justifies it. The work will be done under the direction of the supervisor, and advantage taken of all assistance possible from his regular force, particularly men who have had special training in reconnaissance work on the National Forests.

Forest officers in charge of working-plan parties should use wide discretion in the data which are to be obtained. Data which can not be used for some definite purpose should not be secured, and every effort should be made to obtain all data which will be needed.

Only data needed obtained.

As far as possible all data in the working plan report will be tabulated with brief notes of necessary explanation. While working plans must be complete, every possible effort will be made to eliminate unnecessary discussion and to put them in concise form. All detailed data relating to climate, geology, soil, growth studies, silvical notes, etc., should be placed in the appendix of the working plan, and everything in the plan subordinated to the actual scheme of management for the Forest.

Tabulation of data.

All working plans will be referred to the office of silviculture in the districts and the branch of silviculture in Washington for the proper correlation of the parts. In each case the approval of the offices and branches in charge of the phase of the work under consideration will be secured.

Correlation of parts of plan.

Working plans will be approved by the Forester. Changes not affecting the general policy or the broad features will be approved by the district forester, with reference to the Forester of any points necessary under the administrative instructions.

Approval of plans.

The general ground to be covered by working plans is as follows:

Under "General administration" the topics listed for preliminary plans should be discussed with such further detail as more intensive study makes possible.

General administration.

Under "Silvicultural management" the topics listed for preliminary plans should be developed with much greater accuracy and in much greater detail. Special points will be emphasized and special data obtained in accordance with the administrative needs of the Forest.

Silvicultural management.

To secure uniform data from the National Forests in each district, the district forester will decide upon standard field methods. Standardization will include:

Standard methods in districts.

1. Methods of making estimates under specified conditions to secure results of uniform accuracy.

2. The unit for recording estimates in both surveyed and unsurveyed ground.

3. The minimum sizes to which timber will be estimated and a method of classifying reproduction and young timber below this minimum.

4. A scale for field and base maps and the conditions under which contour or hachure maps will be made.

5. The form and character of notes on silvicultural questions, forest descriptions, etc.

6. The principles upon which the silvicultural system, the rotation, the period for which management will be planned in detail, etc.

In each district also, to insure reasonable uniformity under similar conditions, a careful study will be made of the methods of determining the limitation of annual cut under each silvicultural system which will be used, and standard methods established.

Conclusions required in each plan.

In the completed plan the data secured under each topic will be summarized and the conclusions stated. The following points are of special importance:

1. Silvicultural systems based on the most reliable silvical data available, and upon careful observations on the part of the working-plans officer.

2. A carefully drawn set of marking principles designed to put into effect the silvicultural systems recommended.

3. The maximum annual cut to be allowed during the ensuing 10 or 15 years, and the approximate cuts for each period of the rotation.

4. The order in which the important bodies of merchantable timber should be sold.

5. The order in which areas needing artificial restocking should be sowed or planted, and the acreage to be covered during each year of the period for which detailed recommendations are made.

Grazing.

Under "Grazing," technical reconnaissance and special studies should be conducted, following the general ground covered under preliminary plans but with more detail and greater exactness, with such additions as the needs of the Forest warrant. Since detailed grazing reconnaissance is somewhat technical in nature, it should be directed as far as practicable by grazing experts.

Permanent improvements.

The permanent improvement plan for the Forest should be considered and developed as far as may be practicable in connection with the intensive timber estimates and other investigations conducted by working-plan parties.

Forest protection.

The protection plan for the Forest should be furnished to parties conducting working-plan investigations, and recommendations for its modification or extension, as far as may be found advisable, submitted by them to the supervisor.

Uses of Forest land.

Working-plan parties should familiarize themselves with the portion of the preliminary plan dealing with uses of Forest land. Additional data should be secured as far as practicable in connection with timber estimates and other intensive field work. Recommended changes or improvements should be submitted to the supervisor.

ANNUAL PLANS.

The annual reports, estimates, and recommendations submitted on the various lines of Forest work should be based upon the preliminary or working plan for the Forest and should refer specifically to the portions of the plan dealing with the subject in question. They should show how far it is feasible to apply the plan to the work of the Forest during the current or ensuing year, the specific action proposed to put its provisions into effect, and the changes which appear advisable.

General administration.

The annual allotment and appropriation estimates will be included, with such modifications as are necessary, in the portion of the plan dealing with general administration.

Annual recommendations on maximum and minimum stumpage prices and limitation of yearly cut should be submitted to the district forester. These and the planting and nursery reports should refer to the portion of the plan dealing with silvicultural management and indicate any necessary changes in its application. Revisions of the cutting methods advocated in the plan and of other features of its silvicultural management should be submitted whenever they appear advisable, together with any additional data secured on estimates, logging costs, market conditions, etc.

Silvicultural management.

The annual grazing report and recommendations constitute a concise restatement of the preliminary or working plan and its application to the business of the ensuing year. Additional data should be reported and necessary changes from the plan noted.

Grazing.

In submitting the annual improvement estimates a copy of the improvement map of the Forest showing the plan as revised and extended to date and indicating the work of greatest urgency should be furnished the district forester.

Permanent improvements.

In connection with the annual fire report, the fire plan for the Forest should be checked over and necessary modifications noted. The annual planting and nursery reports should include a current revision and application of the portions of the protection plan dealing with rodents. Special reports and revisions of the Forest plan as regards protection from insects and diseases will be submitted from time to time on Forests where this work is of importance.

Forest protection.

In connection with the current business and periodical reports relating to uses of Forest land, the preliminary or working plan should be steadily revised and extended and its data embodied in such recommendations on policy and current transactions as seem advisable.

Uses of Forest land.

FOREST EXTENSION.

POLICY.

Importance.

Reforestation, under methods demonstrated by successful experiments, is one of the most important duties of the Forest Service and forms a part of the regular work on each National Forest where it is undertaken, coordinate with timber sales, grazing, or permanent improvements. While special instructions covering such work will be issued from time to time and special assistance furnished by the district forester where advisable, the supervisor will be held responsible for the effective direction and execution of reforestation work as for any other activity on his Forest.

GENERAL METHODS.

Intensive experiments.

In every district, intensive experiments, with exact control of all factors, should be conducted at experiment stations and elsewhere to determine the best methods of reforestation applicable to the main types in the district where such work is necessary. These experiments will include tests with both native and exotic species. They should serve to check and develop the methods in use and as training schools for the men engaged in forest extension.

Direct seeding.

Direct seeding is, wherever practicable, the cheapest and most rapid method of reforestation. It should be thoroughly tested on the favorable sites in each district and extensively employed on areas when it is found to be successful. To secure the largest results possible in the actual extension of forest growth, direct seeding on sites where reasonable success by this method is assured will constitute the principal work of the Service in reforestation.

Planting.

The growing and planting of nursery stock will be carried on simultaneously with direct seeding where conditions require. This work will be directed with a view to ascertaining the comparative results of the two methods, the sites on which the greater success from the standpoint of cost and results will be obtained from each method, respectively, and the proper relation of the two methods in the future development of reforestation work.

Wild stock.

The use of wild seedlings in localities where they can be gathered and transplanted at a reasonable cost should be thoroughly tested, and developed in so far as the results, in comparison with other methods, warrant.

Partial reforestation.

On large burns or other areas where complete reforestation would necessarily proceed very slowly, the seeding or planting of plots scattered over the tract may be employed with a view to establishing small patches of forest from which natural reproduction will subsequently extend.

SELECTION OF AREAS.

Most favorable sites first.

Until more exact knowledge has been acquired and methods of greater certainty developed, reforestation work on any considerable scale should be restricted to areas where natural conditions are most favorable to success. The aim will be to develop successful methods on such areas, together with much more exact information as to their possibilities and limitations, and then gradually extend the work to less favorable sites.

Watersheds.

Within the restrictions stated above, watersheds used for municipal supply or irrigation should be given first consideration.

Timber production.

Reforestation for the primary purpose of producing timber may be conducted, however, where conditions are peculiarly favorable to cheap establishment and rapid growth, where the object lesson would be of special value, or where there is urgent local need for an additional supply of forest products.

Burns.

As far as possible immediate provision should be made for reforesting recent burns where natural reproduction can not be expected to take place, especially on sites naturally adapted to dense and valuable forest growth.

ORGANIZATION AND SCALE.

Concentration.

The reforestation work in each district and on each National Forest where it is undertaken should, as far as practicable, be concentrated upon a comparatively few projects with reference to most favorable areas for success, minimum cost per unit, and best possible supervision. Small nurseries and small seeding or planting projects whose primary purpose is to inform and interest Forest officers may be conducted where no additional cost to the Service is involved. Aside from such projects and from work of a purely experimental character, reforestation should in the main be centered upon comparatively large, carefully planned, and well-supervised pieces of work on the most favorable sites.

Seed collection.

The collection of as large quantities of seed of desirable species as can be obtained at a reasonable cost will be part of the regular summer and fall work in each district. This work should be concentrated upon areas where seed of the species (and from the locality) desired for the sites on which reforestation is to be conducted can be gathered at the lowest cost. Extensive collection should not be attempted in seasons when the cost of the seed will, on account of the poor crop, be excessive, or when seed of the species desired for concentrated work on the more favorable sites can not be obtained.

In seasons when large seed crops of desirable species are produced and cheap collection on an extended scale is possible it will often be desirable to concentrate largely upon this work and collect sufficient seed for two or more years ahead. The slight loss in the fertility of stored seed will be more than offset by the reduced cost of collection under such conditions.

Nurseries.

Nurseries should, as a rule, be of a size sufficient to produce not less than a million seedlings per annum. Exceptions may be made in cases where specific isolated areas, which can not be supplied from the main nurseries, must be furnished with smaller amounts of stock grown near the planting sites and under similar climatic conditions.

Field seeding and planting.

Aside from purely experimental work, field seeding and planting operations should, as far as possible, be concentrated, at least to such an extent as will eliminate disproportionate overhead charges for supervision, travel, and the like, and make the cost records applicable to future work planned on an extensive scale.

Checking results.

It is of special importance that the results of all reforestation operations be closely studied in the field by district and forest officers to ascertain the reasons for success or failure and enable the experience gained to be intelligently applied to future work. Detailed periodic inspections should be made and their findings incorporated in reports to the district office.

PLANS AND REPORTS.

Forest plans.

Planting plans, included under "Working plans," will be prepared for each Forest and will indicate specifically the extent of the annual planting and seeding which is recommended.

Such plans will be revised each year and the recommended changes submitted with the annual forest plan.

Nursery plans.

Nursery plans, included under "Working plans," will be revised and submitted annually by the supervisor with the annual forest plan. They should be accompanied by the nursery reports.

District plan.

The district plan, which will be compiled from the forest and nursery plans, will be submitted annually to the Forester.

SEED COLLECTING.

Conditions for collection.

A careful examination of extensive bodies of timber is necessary to determine the abundance of the crop and the best localities for collecting. Since cones are much more liable to be affected by insects during "off years," they should be examined before arrangements for collecting are made by peeling off the scales with a sharp knife, cutting toward the apex of the cone. The fertility of the seed can also be determined in this way.

Time for collecting.

The best results can only be obtained by planning and arranging the work early in the season and by organizing it on a sufficient scale to insure completion while the weather is still good and before slow and expensive artificial drying becomes necessary.

Before collecting, it is necessary to determine if the seed is ripe. Since the external appearance of the cones can not be relied upon, the seed itself must be examined. As long as the seed is soft and milky it is still immature. Cones of the same species ripen first at the lower altitudes. Heavy frosts, followed by warm days, mate-

rially hasten the ripening and consequently lessen the time for collection. It is therefore imperative that the equipment be obtained in advance and that the work be expedited in every way possible so that it will be completed before the cones open and before bad weather makes drying difficult or impossible.

Methods of collecting.

Cones may be collected from felled or standing trees and from squirrel caches. Trees should not be cut unless they can be profitably disposed of. Where no cutting is being done and no better method can be found, seed may be obtained from standing trees. The cones can be picked or stripped off by hand or cut from the branches by a heavy knife or pruning shears.

Cones can be obtained easily and economically from squirrel caches, which are generally in the denser stands of timber, either along small streams and wet places, in water and muck, under bushes and fallen tree tops, and along rotten logs.

When extensive collecting is undertaken, it is often advisable to use several or all of the above methods. It is usually cheapest to collect cones by contract at a stipulated price per hundredweight or bushel.

Drying cones.

If cones which open easily are collected early, and good drying weather prevails, it is unnecessary to use artificial heat unless the work is unavoidably delayed. Such cones should, after being thoroughly cleaned of dirt and needles, be spread thinly upon canvas sheets or burlaps and allowed to dry in the sun in open places with southern exposure. After the soil becomes cold and wet a raised platform for the canvas is necessary.

Artificial methods.

It is generally necessary to dry resistant cones, like those of lodgepole pine, by artificial heat. A suitable building should be selected or constructed with tiers or trays from 8 to 10 inches apart arranged around the inside of the room. The trays should be constructed with screen bottoms having a suitable mesh through which the seed can drop upon a canvas sheet on the floor. The temperature of the room should be maintained at 120° to 140° until the cones have opened. Partial ventilation to carry off moisture is necessary.

Extracting seed.

With the less resistant species a vigorous shaking of the opened cones in a screen tray or a thorough raking is sufficient to separate the seed. With the more resistant cones, especially if large quantities are to be handled, a revolving "cone shaker" should be constructed from rough lumber or a dry-goods box, about 4 by 3 by 3 feet, provided with a door and with openings covered by wire screen having a mesh of sufficient size to permit only the seed to pass through. Slats may be nailed lengthwise inside the apparatus, or loose blocks of wood included with the cones, to increase the jarring effect. Trampling the cones is liable to injure the seed.

Cleaning seed.

The best method of separating the wings from seed is by briskly rubbing a small quantity in a tray, with a bottom of $\frac{1}{4}$ or $\frac{1}{6}$ inch mesh wire screening suited to the size of the seed. Seed should not be beaten or rubbed so violently as to crack the coats. A fanning mill fitted with screens of suitable size is one of the best means of winnowing. When this is not obtainable, good results can be secured by slowly pouring the seed from one box

to another in a current of air. Broken leaves and cone scales can be removed by the use of wire screens with different sized meshes. The final process of cleaning can be greatly facilitated if the cones have been screened before drying begins, to remove needles and other foreign matter.

Shipping and storing.

Seed should be expressed in strong sacks boxed or crated. Labels with the following information should be placed inside the sacks: Species, name of Forest, elevation, date, and total cost per pound.

For storing, seed should be placed in bags or sacks and hung in a cool, dry place or, better still, in sealed jars. Necessary precautions should be taken against rodents.

DIRECT SEEDING.

Selection of sites.

The success of reforestation regardless of method depends upon the suitability of the site. The most favorable sites should uniformly be chosen. As a rule, higher altitudes are more favorable for forest growth than the foothills, northerly exposures than southerly exposures, and areas upon which timber has grown than those which are naturally treeless. Areas with deep, loose soil covered with some kind of woody growth, like aspen or brush, except chaparral, are more favorable than those with compact soil and without protective cover. Recent burns, with or without protective cover, are, however, good reforestation sites.

Sites should as nearly as possible be representative of the forest type of the species which it is intended to sow, in respect to soil, altitude, aspect, and moisture.

Marking sites.

Sites will be clearly marked by blazed trees, substantial posts, or piles of stone. Boundary trees or posts will be inscribed P–1, P–2, P–3, etc., according to the number of the plantation. Each season's work will be marked off by stakes inscribed A, B, C, etc.

Broadcast sowing.

Broadcasting without previous preparation of the soil will probably be successful only under especially favorable circumstances, such as on actual forest land, where the soil is loose and moist near the surface and some protection is afforded the young trees against heat and drought. Burned areas covered with down timber or a light brush cover are most favorable for broadcasting without preparing the ground or covering the seed. When denuded forest land is sufficiently open the soil should usually be prepared by scarifying with some kind of a harrow previous to broadcasting.

The area to be sown should be carefully selected, laid off preferably in strips, and substantially marked. The amount of seed to be sown on each strip should be weighed and one strip sown at a time. Medium-sized seed like yellow pine or Douglas fir can be sown by hand. In case of small seed like lodgepole pine, a mechanical seed sower is preferable. In the case of very small seed, such as larch and Engelmann spruce, it may be advisable to mix the seed with fine earth in order to sow more evenly. The sower should go over the area in parallel courses, using one-half of the seed. He should then cover

the area at right angles to his previous course and sow the remaining half. In this way equal distribution of the seed is assured. Any surplus should be sown upon the more favorable parts of the strip.

Seed-spot sowing.

Under this method seed is sown in selected spots which are prepared for its reception. Since some of the seed may be eaten by mice or fail to germinate, liberal sowing in each spot is necessary. This method has the following advantages over broadcasting: The most favorable spots on each site can be selected; the seed is sown on prepared ground and may, if desired, be promptly covered; a comparatively small quantity of seed is required; and the results of the work can be readily determined.

Sowing with a corn planter.

Sowing with a corn planter is an adaptation of the seed-spot method, applicable especially to areas with comparatively exposed soil. It is cheaper than the seed-spot method, since no previous preparation of the ground is necessary. The number of seeds thrust into each hole made by the corn planter can be easily regulated and the earth pressed over them with the foot.

Time of sowing.

Where the snowfall is heavy and remains upon the ground until late in the spring, it is generally best to sow in the fall, since the seed will become covered more fully with litter and soil during the spring thaw and have a chance to sprout early and produce a strong plant before the summer drought begins. If seed is not available for fall sowing it may be sown by broadcasting in winter or early spring upon the snow on sites previously selected and marked. To obtain the best results in spring sowing by the seed spot or other methods, it is necessary to sow immediately after the snow disappears.

PLANTING.

Care of seedlings.

As soon as a shipment of trees is received they should be examined to determine their condition. If the covering around the roots is becoming dry, it should be moistened at once.

Heeling in.

The trees should be removed from the bundles and, unless planted immediately, should be heeled in on or near the planting sites. A cool, shaded situation should be selected with a moist soil fairly free from rock and coarse gravel. A trench should be dug from 10 to 15 inches deep, with one side slightly sloping toward the north. The trees should then be spread along the sloping side, not more than two or three deep, with the foliage and a short length of stem above the ground surface. To insure uniformity in covering, the roots should be well straightened out and evenly placed in the trench. Fine earth should be packed firmly about the roots, leaving no air spaces, and should be kept moist. Other layers of trees may be set parallel to the first row, but there must be at least 4 inches of earth between the rows. To prevent exposure to intense sunlight, the tops should be shaded with brush or sacking.

Spacing.

In field planting, four by four feet to six by six feet are the spacings generally used. The roughness of the planting site and the necessity of putting each plant in the best possible location will often prevent regular spacing; but uniformity is desirable whenever possible.

Time for planting.

Planting should be done in the fall or in the spring before growth begins. In regions where there is a rainy and dry season planting should usually be done at the beginning of the rainy season, as soon as the soil is sufficiently moist and there is a reasonable probability that it will remain so. To prevent growth starting before time for planting, the seedlings should be kept in snow pits or other cool places.

On all sites seedlings should be planted where the soil is the best and where they will be protected from evaporation, as on the northeast side of stumps, bowlders, or brush.

NURSERIES.

Selection of sites.

Since nurseries are necessarily more or less permanent, the greatest care must be exercised in selecting sites. The following points must be considered: Proximity to the planting sites; facilities for shipping to near-by forests; acreage, soil, surface, slope, aspect, elevation, water supply, etc. An altitude at which the largest mixture of forest trees is found and at which most of the important planting types blend is well suited for a nursery. This is usually on real timberland at the lower edge of the actual Forest. A deep, rich, well-drained sandy loam with an admixture of gravel is the best soil. It is exceedingly important that sites suitable for large nurseries be selected and held in reserve for future use.

Preparation of ground.

Nursery sites must be cleared of trees and rocks and the soil broken up, harrowed, leveled, raked, and worked like a garden before seed beds are made. It is often necessary to fertilize heavily with fine well-rotted manure, especially if the soil has been cropped. The beds are usually 6 feet wide and of any convenient length. To insure drainage, they should be raised from 2 to 3 inches above the paths. The paths are usually 18 inches wide.

Seed sowing in nurseries.

The seed may be sown either in drills from 4 to 6 inches apart or broadcast upon the beds. The latter method is preferable, because it produces a much larger number of seedlings from the same area. If sown in drills and by hand, the drills should run across, or if by a drill seed sower, lengthwise of the beds. Machine sowing is preferable in large nurseries.

Time of sowing.

Sowing should ordinarily be done in the spring, about the time when early garden seed is planted in the locality. If done too early, while the ground is still cold and wet, germination will be slow and many of the seeds may rot.

Depth.

Seed should be very carefully covered, since if the cover is too shallow they may wash out and if too deep they may either rot or lie over until another season. A safe rule is to cover small seeds to a depth of about twice their diameter.

Covering.

Firming the bed with a board will prevent the soil from washing when watered. Immediately after planting it is well to cover the beds with a very thin mulch of leaves, moss, needles, or burlap. This keeps the surface moist and hastens germination. The mulch should be thin and light enough to allow the seedlings to break through the surface or, if heavier, should be removed when germination takes place. The material used should

be free from weed seeds. Water in limited quantities should be applied even to mulched beds.

Quantity of seed required.

Enough seed should be sown to provide 30 to 50 plants to the running foot of drill at the end of one year or to produce 250 to 350 seedlings to a square foot in broadcasted beds. Seed of low germination per cent, such as firs, larches, and cedars, should be sown thickly, and species with a higher germination per cent, such as pines and spruce, should be sown more sparingly. Wherever possible, actual germination per cents should be used to determine the exact amount to sow.

Shade.

In practically all situations conifers require partial shade for the first year. This must be supplied artificially in nurseries by covering the seed beds with screens of lath or shakes. Brush may be used for a temporary shade. The shade frames should be supported on stakes from 18 to 24 inches above the surface of the beds and set about 3 feet from each end of the frame. A crosspiece of inch material should connect the stakes on opposite sides of the bed. In semiarid regions or where material is cheap and plentiful a lath house is the best method of shading. One can be constructed by setting posts about 12 feet apart, connecting them at the top, which should be about 7 feet above the ground, with 2 by 4 inch stringers and covering the entire structure with lath or woven-lath fencing. When lath or woven-lath fencing can not be secured readily, brush or light poles may be spread over the framework until half shade is produced.

Care of seedlings. Damping off.

All conifers and some broadleaf species while in the seed beds are subject to damping off, which often destroys a large per cent of the seedlings. It is caused by a fungus which attacks the young plants near the surface of the ground. Dry sand, charcoal, or fine gravel spread on the beds will often check the disease. The proper application of water to the seed beds before and after germination is particularly important. The soil should be kept uniformly moist from the time the seed is sown until the seedlings are a week or 10 days old. After that water should be applied less frequently, though the soil should never be dry enough to powder when dug up. When irrigation is inadvisable, water should be applied with a sprinkling pot or hose and the soil should be thoroughly wet each time. Watering should be done early in the morning or late in the afternoon. Shade frames should remain over the seed beds, except during damp, cloudy days. In localities where heavy rains are followed by high temperature the frames should be raised or removed as soon as the sunshine disappears from the seed beds and kept so until the sun appears the following morning. The drying of the soil may also be hastened by cultivation. This should not be neglected, since proper drying and airing of the soil after rain checks damping off. The same method for drying out the soil should be followed if water has been applied excessively.

Watering.

Cultivation.

Seedlings should be cultivated often, in order to prevent weeds from starting, stimulate growth, prevent damping off, and keep the soil in good condition. Cultivation, which can be done either with a narrow hoe or with a small rake made of nails, should be shallow and should pulverize the soil thor-

oughly. It should be done after rains or whenever the soil shows signs of baking or drying.

Protection in winter.

Where winters are severe, it is advisable to mulch the seed beds to protect the seedlings from injury by cold or drying winds, as well as to keep the ground from heaving in the spring. Where snow lies all winter, mulching is unnecessary. Any substance, such as leaves, straw, or moss, which is free from weed seed, placed in a layer from 3 to 4 inches deep, is suitable. The mulch can be held in place by laying sticks or strips of boards across the beds between the rows. It should be removed at the beginning of the growing season.

Transplanting.

In the spring, when the soil is in good workable condition, but before a new growth begins, evergreen seedlings when 1 or 2 years old should, in some cases, be transplanted to open nursery rows. Transplant beds should be near the seed beds and on good soil which has been thoroughly prepared. Transplant beds should be slightly elevated, 6 feet wide, and of any convenient length, with rows 8 inches apart running across the beds. The seedlings should be set free from 2 to 4 inches apart in the rows, the exact distance depending upon the size of the plants. In transplanting the roots of the seedlings should not be allowed to become dry, since even a short exposure to sun or air will be fatal. They can best be carried roots downward in a pail containing 4 or 5 inches of water.

PROTECTION AGAINST RODENTS.

Importance.

Great damage is done by mice, wood rats, squirrels, chipmunks, gophers, and rabbits in nurseries, seeding areas, and young plantations. Before establishing a nursery or plantation or seeding denuded areas, therefore, the presence of destructive rodents should be carefully investigated.

Cost.

The cost of the protective method adopted must be worked out in detail, as it may be found upon investigation that really effective protection will cost more than the results justify, and that it will be preferable to abandon the project and select a new site in a less infested locality.

Fencing.

For the protection of nurseries against rabbits a small-mesh chicken-wire fence may be used. This should reach at least 3 feet above ground and one-half foot below. The portion below the surface should be bent in toward the ground to be protected at an angle of 45°, so that the burrowing animal will come up against it diagonally when trying to reach the surface.

Traps.

Many types of traps for catching rodents are in use. Forest officers engaged upon such work should fully investigate their effectiveness. Information concerning special kinds of traps may be secured from the Biological Survey upon application through the Forester.

Poison.

The best results in the extermination of rodents have been obtained from the use of poison. The following formulas and directions are recommended by the Biological Survey after a series of experiments in the field:

During the growing season, when there is an abundance of green food, green or ripening barley or wheat heads should be used; later, after the crop is harvested and the dry season sets in, whole barley or wheat may be used as follows:

For ground squirrels.

Grain	20 pounds.
Strychnine (pulverized)	1 ounce.
Saccharine	1 teaspoonful.
Water	1 quart.
Starch	2 ounces.

Soften the starch in the water, which should be cold, or nearly so, then heat to boiling, stirring the mixture as the starch thickens. Add the strychnine and saccharine, and mix thoroughly. Pour slowly over the grain (mixing continuously) until the heads or kernels are evenly coated. In this case barley is preferable to wheat, as ground squirrels take it quite as freely as they do wheat, and it is less likely to be eaten by birds. The mixture should be scattered along runways and about a teaspoonful placed in the entrance to each hole.

For gophers.

Gophers may be readily destroyed by means of strychnine applied to sweet potatoes, parsnips, carrots, or soaked corn, chopped to the size of small marbles.

Roots or corn	1 bushel.
Strychnine (powdered)	1 ounce.
Starch	2 tablespoonfuls.
Water	1 quart.

Prepare this bait in the same manner as for ground squirrels, taking care to see that the poisoned starch is evenly distributed. If corn is used, it should be soaked until soft—the process can be hastened by heat—then the surface of the kernels allowed to dry before the starch mixture is applied to avoid excessive moisture.

By means of an iron rod the burrows of gophers may be located near their mounds. Through the holes thus made about a tablespoonful of the bait should be introduced into each burrow. The holes need not be covered. Gophers are most easily poisoned when the ground is damp. Not only are they less active in the dry season, but dry crumbling soil renders it difficult to place the poison properly in the runs, under which conditions traps should be used.

For mice and chipmunks.

The following preparation has been used with good effect in the destruction of mice and chipmunks:

Strychnine	1 ounce.
Saccharine	¾ teaspoonful.
Laundry starch	½ cupful.
Water	1 quart.
Barley	20 pounds.

Dissolve the strychnine and saccharine in the water by boiling; stir in the starch after having softened it in cold water, and continue boiling until the solution thickens; mix thoroughly with the grain until the kernels are all coated. The mixture may be used at once or dried and kept for future use. It should be distributed in cavities among small piles of stones, under roots, or under pieces of bark or flat stones raised an inch or so off the ground in order to keep it out of reach of birds. The baiting places should be numerous and only a small quantity left in each.

The following formula for poisoning small rodents has also been found very successful in direct seeding in the Black Hills:

Wheat	1 bushel.
Tallow (preferably mutton or beef)	1 quart.
Strychnine sulphate	2 ounces.
Saccharine	2 teaspoonfuls.

Warm the wheat as much as possible without burning it. Pour on the tallow melted and stir until thoroughly mixed. Pulverize the strychnine completely, add this and the saccharine to the wheat while still warm, and again mix thoroughly. The poisoned grain can be spread by men walking on parallel lines about 15 feet apart and dropping from 10 to 15 grains every 3 or 4 feet. Distributed in this way, a bushel of wheat will poison about 40 acres. Poisoning should be done at least a week in advance of sowing and when the weather is dry, so that the poison will not be washed off.

For rabbits.

Both cotton-tail and jack rabbits take poisoned bait more readily in winter or early spring than at other seasons. For rabbits the following preparation has been found effective:

Young shoots of alfalfa or green twigs from fruit trees or native brush, cut into 2 or 3 inch lengths	15 pounds.
Water	1 gallon.
Strychnine sulphate	1½ ounces.
Saccharine	½ teaspoonful.

Dissolve the strychnine and saccharine in the water and allow it to cool. Press the alfalfa shoots or twigs into the solution until covered and allow them to steep three or four hours. This bait should be scattered in small heaps, a few hours before sundown, along the runways or about the area to be protected.

Red lead and coal tar.

Coating the seeds themselves with red lead has so far not proved an efficient protection. Further experiments on a small scale in the use of red lead, and also in coating seeds with coal tar, are, however, desirable.

Cooperation with the Biological Survey.

When the damage done by rodents becomes serious and the methods of extermination used are unsuccessful in reducing their numbers below the danger point, the Forest officer in charge should report the matter in detail to the supervisor. The supervisor will submit a report in triplicate to the district forester, who will forward the original and one carbon to the Forester for transmittal to the Biological Survey. The Biological Survey will reply in triplicate through the Forester and district forester, each of whom will retain a carbon copy of the reply. Specimens of the species causing the trouble should be secured for positive identification. The skin of the animal, with the skin of the head, feet, and tail left on, should be thoroughly salted with fine salt and dried; the skull should be roughly cleaned by carefully cutting off the larger muscles and removing the tongue, and the brain removed by a slender stick or bent wire. The skull should be labeled with a tag numbered to correspond with a similar tag attached to the skin. The skull should then be hung up until dry. Great care should be used to avoid breaking the skull, since the proper identification of the species may depend upon its being unbroken. When the skin and skull are dry, they should be forwarded directly to the Biological Survey, accompanied by a statement as to the date and place of collection, name of collector, and proper reference to the report on the matter.

FOREST INVESTIGATIONS.

Importance.

Forest investigations of a thorough and systematic character and conducted with scientific accuracy form an important part of the work of the Forest Service, both as a means of building up the science of forestry in the United States and of directly assisting and improving the administration of the National Forests. The assistance and cooperation of all members of the Service in conducting investigations are essential.

Service organization.

As far as practicable the investigative work of the Service will be directed by a central committee in the Washington office, to be designated by the Forester, working in cooperation with the respective branches. A specialist in investigative work shall act as chairman of the committee, and shall, subject to its recommendations and the direction of the Forester, review all plans for investigative work, correlate the projects proposed by the different branches and districts, and exercise general supervision of the work initiated in the districts and under the Washington office. The central committee will take action through recommendations submitted to the branch chiefs. Differences in judgment between the committee and the branches will be submitted to the Forester for decision.

District organization.

As far as practicable the investigative work in each district will be directed by a district committee, to be designated by the district forester, working in cooperation with the chiefs of the respective offices. A specialist in investigative work shall act as chairman of the committee, and shall, subject to its recommendations and the approval of the district forester, review and correlate all projects for investigative work in the district, devise methods for carrying out general plans initiated by the central committee, and exercise general supervision of the work done under the various projects in the district. Action will be taken through recommendations submitted to chiefs of office.

Kinds of investigative work.

The general kinds of investigative work which will be conducted in the districts are: General silvical studies, experiment stations, special silvical studies, studies of range improvement, studies of insect infestations, studies of tree diseases, investigations of methods and results of wood preservation, of forest products, and studies of general market conditions.

Preliminary plans.

Before any investigative project, including studies conducted on all National Forests, is undertaken a plan of work covering its purpose, scope, relative value, approximate cost, and the results of previous studies, which will be utilized, will be prepared and approved with such modifications as may be necessary by the district forester or branch chief concerned and by the district or central committee.

GENERAL SILVICAL STUDIES.

Silvical description.

On each National Forest a complete silvical description of the forest types and characteristics of the species composing them should be worked up and extended from time to time. The following ground should be covered:

I. The Forest.

1. A complete list of trees, giving the scientific names and all common names in use.

2. A complete list of shrubs.

3. The fundamental forest types into which the Forest is divided and the factors which differentiate them (climate, exposure, topography, altitude, soil, etc. The proper basis for separating forest types is the physical conditions of the locality, and not the composition or age of the stand or any other variable condition.)

4. General silvical description of each type, to include:

(*a*) Its approximate proportion in the Forest.

(*b*) Its physical conditions of site, such as climate, soil, altitude, topography, exposure, etc.

(*c*) Its forestal characteristics, such as composition, interrelation of the various species, even or uneven aged stands, ground cover, humus conditions, etc.

(*d*) External influences which are operative in the type, such as fires, grazing, storms, etc.

(*e*) Recommendations for the silvicultural management of each type.

(*f*) The division of each type into subtypes on the basis of differences in composition, age, etc., and the presence of temporary types, discussing the cause and future of each temporary type.

II. The Species.

1. Habit: Average mature and maximum diameter and height. Form of crown and bole at different ages. Root system at different ages and under different conditions.

2. Occurrence: Distribution throughout the Forest and the effect of altitude, exposure, soil, atmospheric and soil moisture, and other factors, in limiting its distribution; the species with which it is commonly associated.

3. Soil and moisture: Preference of each species as to soil. Requirements in regard to soil and atmospheric moisture. Arrange the species in order of their demands for soil quality and soil moisture.

4. Tolerance of shade: Tolerance of each species at different ages. Compare its tolerance with that of its important associates by means of a scale of tolerance. Discuss its ability to grow in dense shade, in dense stands, and to recover from suppression.

5. Growth and longevity: Rapidity of height and diameter growth of all species. Compare with associates. Give growth tables when possible. Average age to which each species remains sound and vigorous. Maximum age recorded.

6. Reproduction: (*a*) Seed production—Abundance of seed production and frequency of seed years. Method of seed dissemination. Time at which seed is disseminated. Agencies which destroy seed and decrease its vigor.

(*b*) Seedling development—Time of germination and appearance of seedlings. Conditions which are favorable or detrimental to germination and early development of the seedling.

(*c*) Sprouting—From stump, root, or both; vigor and permanence of sprouts.

7. Susceptibility to injury: Effect of wind, frost, lightning, fire, etc., on each species. Effect of grazing, giving the nature of the benefit or injury. Liability of the species to attack by fungi and parasitic plants, discussing fully any special instances of vegetable parasitism. Liability to insect attack, discussing fully any special instances of insect infestations. Injurious and beneficial effects of animals and birds.

This general study on each Forest should be conducted by the forest assistant with the cooperation of other members of the force. It should be cumulative, the results recorded being corrected or extended as additional data are secured. Its aim is to make available in concrete form on each Forest all of the silvical information accumulated by the members of the Service working upon the Forest. The forest assistant or other officers on the Forest may be called upon from time to time by the district forester to submit reports, either embodying all of the general results secured to date or dealing with special topics under the general study.

Cut-over Areas.

Cut-over areas.

Studies of cut-over areas should be conducted as far as practicable on every Forest where timber sales have been made. Their object is to determine the best methods of management to use in different types in order to secure natural reproduction and the maximum production of wood. Records should therefore be kept of as many areas as possible in different types which have been cut under different systems of management. Such studies should be conducted by any competent man, although special attention should be paid to them by the forest assistants.

The following outline should be covered:

(Case designation and date of examination.)

1. Original cutting area: Location, date, altitude, slope, soil, ground cover, forest (age, conditions, special features), method of cutting, stand left, burns, grazing, brush, reproduction.

2. Results of cutting: (*a*) Soil changes—Duff, litter, underbrush, grass, erosion.

(*b*) Stand changes—Growth, windfall, death, insects, fire, grazing.

(*c*) Reproduction—Increase, species, distribution, damage, inferior species, seed production (seed trees).

(*d*) Miscellaneous—Stream flow, range conditions, etc.

Ordinarily the forest description contained in Form 578a accompanying the timber sale will be sufficient, but should be supplemented whenever necessary. Since the cut-over area reports are filed separately, they should be accompanied either by the original forest description or a reference to it. This portion of the report will be necessary only in the first examination. Subsequent examinations should be made as often as necessary to follow closely all changes that take place on the area, usually at intervals of not more

than three or four years. Reports on these examinations may be called for as deemed advisable by the district forester.

Reports on current methods.

The district forester may, as he deems advisable, call upon forest assistants or other officers for special reports dealing with current methods of marking, estimating, brush disposal, seed collection, combating insect infestations, and other matters of a technical character.

Small Forest experiments.

Small experiments, initiated by the supervisor or other Forest officers, in silvical investigations, reforestation, range improvement, and the like, whose primary object is to inform and interest the field force and which are conducted at slight cost under the regular Forest allotments, are encouraged.

EXPERIMENT STATIONS.

Stations for intensive investigations, including long-time experiments and the development of methods of exact research, will be established from time to time on selected Forest areas. Such stations will form an integral part of the investigative work of the district and will be under the direction of the district forester. Substations, conducting studies similar to those at the main station and under the direction of the officer in charge of the main station, may be established as far as necessary to include a range of forest conditions typical of the entire district.

Relation to supervisors.

The Forest officer in charge of the experiment station will have the same relation to the district forester as a supervisor, and will report directly to the district forester. He will have no authority in the administration of the National Forest, excepting areas withdrawn for experimental purposes. The supervisor will have no jurisdiction over experimental areas aside from furnishing the necessary protection. Areas to be used for experimental purposes will be withdrawn only upon mutual agreement between the officer in charge of the station and the supervisor. In case of disagreement, the matter will be referred to the district forester for settlement.

Cooperation.

The experiment station should cooperate fully with other bureaus of the Government, and with private institutions and individuals, at the discretion of the district forester.

Subjects for study.

The investigative work conducted at experiment stations covers three main groups of problems: Forest problems proper, including individual tree studies and stand studies; problems concerned with the indirect influences of the forest; and problems concerned with artificial reforestation.

Tree studies.

Individual tree studies will embrace chiefly investigations of the silvical characteristics of different species, such as habitat, light, moisture, and soil requirements, form and volume, growth, reproduction, phenology, and enemies and diseases. The requirements of trees should be studied not only by general observations, but by actual measurements of the physical factors affecting their growth, and the results should be expressed, as far as possible, in absolute figures.

Stand studies.

Studies of stands must be largely studies of types, their origin, characteristics, development, and permanence. They should include the preparation of yield tables and studies of various methods of improvement and reproduction cuttings. The aim will be to produce in each type characteristic of the region a model forest. These model forests should be used for experimental purposes and to demonstrate methods applicable in timber sale management.

Indirect influences.

Studies of the indirect influences of forests should include thorough investigations of the effects of forests upon meteorological conditions, temperature, humidity, precipitation, evaporation, and wind velocity, and upon run-off and water supply.

Artificial reforestation.

Special emphasis should be given to exact studies of the conditions involved in the reforestation of denuded areas, such as soil moisture, evaporation, seasonal conditions, presence of rodents, and the like, and to intensive experiments calculated to develop the best methods applicable to the various types in the district.

SPECIAL SILVICAL STUDIES.

Special investigations, covering the entire district or an individual Forest or group of Forests, will be conducted to supplement the work of the experiment stations. They will be of the same general character as the studies prosecuted at the stations and will be made under the general supervision of the district forester either by men assigned to Forests under the direction of the supervisors or by specialists detailed from the district office.

RANGE IMPROVEMENT.

Cooperation with the Bureau of Plant Industry.

Studies of range improvement will be conducted either in connection with experiment stations or as special projects initiated by the Forester or the district forester. They embrace the restoration of depleted ranges to normal or maximum productivity, the development of ranges through the introduction of better forage plants, and the most economical utilization of forage crops. Such studies should be reviewed by the district committee and correlated as far as practicable with silvical investigations conducted upon the same types, but will be under the immediate direction of the district chief of grazing or of grazing experts. The general plan for each project which involves a study of plants and grasses must be approved by the Bureau of Plant Industry through the Forester before the work is begun. Specimens of plants and grasses may be sent to the Forester for identification by experts employed jointly by the Forest Service and the Bureau of Plant Industry.

INSECT INFESTATIONS.

Cooperation with the Bureau of Entomology.

Studies of insect infestations will ordinarily be made by experts of the Bureau of Entomology in cooperation with the Forest Service. They may, however, be included in the subjects assigned to men detailed to make special investigations or to Forest officers for report.

Insect damage—ranger's procedure.

When a ranger or other Forest officer discovers the work of harmful insects which are a menace to the Forest, he will report fully by letter to the supervisor. He will also, if practicable, obtain several specimens of the insect and send them securely packed to the supervisor, together with a small section of the part of the tree infested. If the damage is caused by bark beetles, the section should be large enough to show the form of the galleries.

Supervisor's procedure.

The supervisor will satisfy himself as to the extent of the attack by a personal field inspection, or by a report from some competent Forest officer, and submit a report in triplicate to the district forester. If there is a field agent of the Bureau of Entomology in the district, the matter will be taken up with him through the proper channels. He will, whenever possible, personally investigate the infested area and recommend methods for controlling the attack.

If there is no field agent of the Bureau of Entomology in the district, or if the immediate advice of the Washington office of the bureau is desired, the district forester will add his recommendations to the supervisor's report and forward the original and one carbon of the report to the Forester for transmittal to the branch of forest-insect investigations in the Bureau of Entomology. The Bureau of Entomology will reply in triplicate through the Forester and district forester, each of whom will retain a copy of the reply. The Forester will authorize the necessary action, while the application of the recommendations made by the Bureau of Entomology will be carried out under the direction of the district forester. Specimens of insects and their work should be sent by the supervisor directly to the district field agent or to the branch of forest-insect investigations in the Bureau of Entomology, as the case may be, and should be accompanied by a statement as to the date and place of collection, name of collector, species of tree attacked, and proper reference to the report on the matter.

In the case of large infestations special arrangements will be made for cooperation.

TREE DISEASES.

Cooperation with the Bureau of Plant Industry.

Studies of tree diseases will ordinarily be made by pathological experts of the Bureau of Plant Industry in cooperation with the Forest Service. They may, however, be included in the subjects assigned to men detailed to make special investigations or to Forest officers for report.

Procedure.

Where large blocks of timber are threatened with damage by disease, the same procedure will be followed as outlined for "Insect damage," except that specimens and reports will be referred to the consulting pathologist, if there is one in the district, or, if not, to the office of investigations in forest pathology, Bureau of Plant Industry, Washington, D. C. All specimens should be accompanied by a statement as to the date and place of collection, name of collector, name of the tree on which the specimen was found, and proper reference to the report on the matter. Fleshy fungi, which are likely to decay in transit, should either be thoroughly dried before being sent, or should be sent in some preserv-

ative liquid such as alcohol or vinegar. Specimens should be sent by mail whenever possible, otherwise by express, charges collect.

The district forester after consultation with the consulting pathologist, or the Forester after consultation with the proper official of the Bureau of Plant Industry, will issue instructions and authorize the necessary action.

FOREST PRODUCTS INVESTIGATIONS.

Correlation with other studies.

Studies in forest products, including wood preservation, utilization studies, and general market investigations, are covered in the Products section of the Manual. Such studies will be conducted under the immediate direction of experts in products but should be reviewed by the district committee and correlated as far as practicable with other investigative work.

REPORTS.

Experiment station—annual.

The Forest officer in charge of each experiment station will submit to the district forester during January a full annual report in duplicate upon the work of the station, together with plans for the coming year. He will also from time to time submit such other reports and plans as may seem to him advisable or be required by the district forester. A copy of the annual report and of other reports of special importance will be sent to the Forester.

District—annual.

The annual silvical report of the district to the Forester is due in February. This report should consist of a brief summary of the important silvical projects undertaken and the results obtained at the experiment stations and elsewhere, and an outline of plans for future work.

Reports from Forests.

All investigative reports from Forests should be prepared in quadruplicate. One copy should be retained by the supervisor and three copies forwarded to the district forester, who will in turn forward a copy to the experiment station and one to the Forester in case the report is of sufficient importance to make this advisable.

Reports from experiment stations.

All reports from experiment stations will be forwarded in duplicate to the district forester, who will send one copy to the Forester.

Card records.

A card record, Form 485, in duplicate, should be kept of all studies, including those of cut-over areas, being conducted on each National Forest and at experiment stations. One copy should be kept on file at the office of the supervisor of the National Forest or of the Forest officer in charge of the experiment station, and the other at the district office. When an experiment is terminated, the card should be stamped "closed," and transferred to a closed file.

Publications.

It is the policy of the Service to publish results of investigative work conducted by its members which are of definite scientific value or of general interest. In addition to the publication of the results of specific pieces of work, as bulletins or circulars, publications embodying the general progress of the Service in investigative work, including extracts from reports which do not merit separate publication and references to all field projects where useful work is being done, will be issued from time to time.

LIBRARIES.

DISTRICT LIBRARIES.

Supervision.

District libraries will be under the supervision of the office of silviculture.

Receipt for books.

Upon receipt in the district office of books from Washington the card (Form 185) will be signed and returned, and the subject and author cards filed alphabetically in the card catalog. At the beginning of each calendar year a list of books charged to each district office will be sent in duplicate to the district forester, who will approve one copy and return it to the Forester.

Receipt for periodicals.

The receipt of periodicals will be recorded on Form 183, and the Forester notified of any failure to receive them regularly. Such periodicals as contain articles of permanent value may be sent to Washington for binding when a volume is complete.

Use of books.

Any member of the Forest Service may borrow any number of books from the district libraries. Books for which calls arise must be returned within two weeks.

Charge cards.

When a book is loaned, a charge card (Form 172) will be signed by the borrower, the date entered, and the card filed alphabetically by author. When the book is returned the date will be entered over the signature of the borrower and the charge card returned to the book pocket. Books needing rebinding will be sent to Washington and the fact noted on the charge card. The file of charge cards will be examined on the 1st of each month, and those who have had books more than a month will be notified.

Purchase of books.

All requisitions for the purchase of books, periodicals, or magazines must be approved by the library committee at Washington and the order placed with the publisher by the purchasing agent. Suggestions as to books which should be included in the district libraries should be made through the district forester.

Photograph collection.

A collection of photographs illustrating forest conditions and administrative methods on the National Forests and elsewhere should be kept in the district library in the manner prescribed by the district photograph committee. Prints of pictures desired for the collection may be secured by requisition on the Forester.

SUPERVISORS' LIBRARIES.

Supervision.

To aid the work of Forest officers, supervisor's offices are provided with small libraries of books on forestry and allied subjects. These libraries will be under the direction of the Washington office. Whenever a supervisor desires a book he should make requisition for it by letter in duplicate, containing a brief statement of the necessity for the purchase, to the district

forester. If he approves the requisition, he will forward the original to Washington for action, and retain the carbon for his files. Thereafter the matter will be handled by the Washington office, which will correspond directly with the supervisor. Copies of such correspondence will be sent to the district forester for his information. In case the Washington office does not agree with the district forester's recommendations, the matter will be taken up directly with the district forester and not with the supervisor. Form 229 will be sent to supervisors to notify them of each consignment of books shipped.

Charge cards. Charge cards will be used for books in supervisors' libraries, as described for district libraries.

List of books. At the beginning of each calendar year a list of books charged to each supervisor will be sent in duplicate to the supervisor, who will approve one copy and return it to the Forester. A copy of this list will also be sent to the district forester for his information.

Use by rangers. Rangers should be encouraged to use library books as much as possible in the supervisor's office, and by borrowing them for use at home. Special reading courses may be used to good advantage in familiarizing rangers with material in the library, and circular letters may be sent out at intervals by supervisors listing the books on particular subjects.

Photograph albums. Photograph albums illustrating general forest conditions and forest activities in different parts of the country, and local conditions and activities on the National Forests, will be kept as a part of the supervisor's library, as prescribed by the district photograph committee. Prints of pictures desired for the album may be secured by requisition on the Forester.

DISTRIBUTION OF FOREST SERVICE PUBLICATIONS.

To libraries. Copies of all Forest Service publications, marked "File copy," will be sent as soon as issued to all district and supervisors' libraries. The library copies will be placed in temporary binders requisitioned from the Ogden supply depot. Bound volumes for the Washington and district libraries will later be supplied from Washington.

To ranger stations. Each permanent ranger station will receive copies of selected publications. These will be stamped "File copy, ——— ranger station," and the name of the station filled in before mailing to the supervisor. These will be filed at ranger stations without binders. When changes or additions in headquarters are made, the Forester should be promptly informed.

For office use. A supply of each new publication will be sent to each district forester for office files and for use in office interviews and in correspondence requiring the use of marked copies.

For personal use. Single copies of publications for the personal use of members of the Forest Service will be sent on request to the Forester.

COOPERATION—DISTRICTS.

DEPARTMENTAL COOPERATION.

This cooperation varies so greatly in scope and character that it has no fixed procedure. The essential points are that the correspondence leading to cooperation and the reports upon it will be transmitted through the Forester, but that the work itself will be handled by the district office. All formal agreements with other departments will be executed by the Secretary. Recommendations for new projects should always include an estimate of cost, which, when small, or when the importance of the work justifies it, may be borne wholly by the Service.

STATE AND PRIVATE COOPERATION—FOREST MANAGEMENT.

State cooperation.

Important letters to State officials regarding cooperative forest work which they have requested, or transmitting formal agreements, reports of investigations, and recommendations for action by the State will be prepared in the district office and submitted, with two carbons, for the signature of the Forester. Agreements will be signed by the Secretary. One carbon of agreements, reports, and letters to State officials will be retained in the Washington office.

Private cooperation.

It is the policy of the Forest Service to make examinations in the field in cooperation with private owners only where the information obtained will be of scientific value to the Service or where there is an opportunity to interest residents in conservative management and tree planting in regions where little or no practical forest work has been done. The aim is to assist the small owner especially, and it is preferable to make examinations for a number of owners in one locality so that the work may have as far-reaching effects as possible. Applicants for detailed field examinations should be referred to State foresters in every case where these officers are able to make such examinations; or they may be referred to private foresters.

Procedure.

Agreements for cooperation in forest management with private owners will be approved by the district forester, and all correspondence will be handled by the district office. When a proposed project involves a radical departure from existing policy or an increase in the Forest force, the district forester will submit the application for such cooperation, with his recommendations, to the Forester for decision.

Requests for private cooperation will be satisfied by letters of advice when possible, or by field examination if considered necessary, after formal application has been made on Form 704, in accordance with the terms of Circular 165. The applicant will be furnished with Form 861 filled out to accompany each deposit.

Reports upon cooperative studies with private owners will be prepared in accordance with the "Outline for examination of private forest lands." Reports on the practice of forestry on private lands will be made on Form 216.

Reports.

Since extra copies of reports upon cooperative studies are often needed to meet requests for advice, at least two extra copies of each report will be filed with the correspondence in the case folder.

A card index will be kept in which applications for cooperation involving field studies will be filed alphabetically by name of applicant and location, and subsequent steps recorded.

COOPERATIVE PLANTING.

Assistance in forest planting will be furnished under the terms of Circular 165. Applications will, so far as possible, be satisfied by letters of advice, transmitting suitable planting circulars and lists of dealers.

Procedure.

Where a cooperative study is advisable, the applicant will be furnished with Form 728 and Form 861 filled out to accompany his deposit. Planting plans based on field study will be prepared in accordance with the instructions in "Planting plan studies and reports." One copy will be sent to the cooperator and at least two extra copies kept in the case folder. Studies of established plantations will be reported in accordance with the instructions in the "Plan for study of forest plantations."

Cooperation in planting with other branches of the Federal Government or with States will follow the routine prescribed for State and departmental cooperation.

Departmental and State.

The Forest Service will in special cases furnish stock, particularly for planting on important watersheds within National Forests, but only for purely experimental planting. Annual reports of results will be required.

Furnishing stock.

A reminder card record will be kept of all correspondents who plan to do commercial planting, in order that cards (Form 891) may be sent them later for reports on the results obtained. When correspondence indicates that planting has already been done such cards will be sent at once. When returned they will be filed under the States in which the plantation is located, alphabetically by species and the names of the cooperators.

DENDROLOGY.

Each district forester will be supplied with folio maps showing the ranges of all species occurring within his district. The ranges will be complete so far as available records can make them so. Extensions of range discovered within each district, after the maps are received, should be promptly added to the map or maps on file and a transcript of the addition on tracing paper forwarded to the Washington office for record. The Washington office maintains a set of tree distribution maps for North America and desires the systematic cooperation of the district foresters in making these records as complete as possible. All extensions of range discovered by the Washington office will be promptly forwarded to the district foresters concerned.

Data on range of trees.

In case of doubt as to the identity of a species, of which extended range is discovered, adequate specimens, flowers, if possible, but in all cases mature foliage, together with mature fruit whenever this is obtainable, should be forwarded to the Forester for identification. Notes should accompany the specimens, giving as accurately as possible the location of the species found and the extent to which it occurs; also the character of soil, aspect of slope, approximate (if not exact) elevation, associated species, how the species occurs—scattered, in open, dense, or continuous stand. When necessary to name small, little-known streams, lakes, mountains, etc., as locations for new ranges, these must be connected by reference with larger well-known streams, watersheds, etc., so that the area can be accurately located on a map.

Identification of species.

District Forest officers are urged to cooperate as fully and as diligently as possible with the dendrologist in obtaining full and accurate records of the horizontal and vertical ranges of trees within their respective districts. Present knowledge of the ranges of our trees is very imperfect. For many species it is only general, requiring much careful exploration to work out the actual limits. Definite records of occurrence, even within the generally known range, are desirable, while those which permit drawing outside limits of a range are particularly valuable.

All field reports, notes, etc., describing the occurrence of trees, should preferably refer to species by their technical names; otherwise the accepted common name of the Check List (Bulletin 17) should be used. Use of such indefinite or confusing names as piñon, juniper, cedar, cypress, mountain mahogany, magnolia, spruce, larch, fir, oak, etc., should be avoided when describing or referring to a particular species. Much valuable, and probably new, information in field reports which include matter on the geographic ranges of trees can not be used now because the unfortunate use of such indefinite names makes it impossible to be sure what species the writer saw.

Indefinite common names of trees.

COLLECTION AND PREPARATION OF SPECIMENS.

Service herbarium at Washington.

It is desirable to have represented in the herbarium of the Forest Service at Washington (which includes a collection of woods) duplicate specimens of all species collected in the different districts. The Washington herbarium is a permanent reference collection used not only by the Forest Service, but to a very great extent by other bureaus of the Department of Agriculture. In order that the collection may be widely useful, it is necessary that it be made as comprehensive as possible. This can be accomplished only by the combined efforts of all Forest officers. Directions for collecting and preparing foliage, wood, bark, and other specimens are given in the circular of March 5, 1910, prepared by the dendrologist.

District herbaria.

The dendrologist will name and have mounted reference sets of tree and shrub specimens for each district. The work can be done more economically in Washington than in the district offices, which are not regularly equipped, nor does it seem desirable to equip them, for such temporary work. The dried specimens can be safely forwarded and returned by mail under frank. Duplicate specimens designed for the Washington herbarium should be sent in at the same time.

Herbaria of forage plants.

Collections of important forage plants are useful to familiarize Forest officers with them and to enable them to obtain a knowledge of their uses, life history, and relationship to other plant life of the National Forests. To be fully useful, representative specimens should be collected and carefully preserved. They should be accompanied by notes describing how each species grows, and particularly how much the species is used for food by the stock.

Unless good complete specimens are collected the material can not be satisfactorily identified. Flowers, fruit, and mature foliage should be represented in all sets of specimens gathered, while in the case of herbaceous plants the specimens collected should include roots. If such plants grow in bunches, enough of the clump should be preserved to show the root habit. Before putting the specimen in the press, the earth should be shaken, rather than washed, from the roots in order to preserve the natural spread of the root system. If the plant should be too large to lie on a sheet $11\frac{1}{2}$ by $16\frac{1}{2}$ inches, the stem may be bent into an N or M shape, the angles being held in place by strips of heavy paper or cardboard 2 to 3 inches long and $\frac{1}{2}$ to 1 inch wide, with a slit 1 to 2 inches long through the middle. One of these slipped over the stem will hold the specimen firmly.

Collected specimens should be placed between sheets of newspaper, or preferably the plain, thin, collecting sheets interspersed alternately with two or three sheets of blotting paper, and placed between boards or a wicker press and subjected to a pressure of from 25 to 40 pounds. This may be applied by tightly drawn straps or by a weight. Stems, roots, and other parts of herbaceous plants over a quarter of an inch thick should be thinned (by cutting) before pressing. The blotters should be changed each day until the specimens are dry.

At least two specimens of each species should be collected, in order that one may be forwarded to the Forester for identification.

Field notes.

As each specimen is placed in press it should be given a number on the outside of the containing sheet in the order of collection. These numbers should be entered in a notebook and each should be accompanied by notes covering the following points:

1. Date, place of collection, and by whom collected.
2. Geographical distribution.
3. Altitude.
4. Habitat (as low moist meadow, sterile knoll, salt marsh, etc.).
5. Habit of plant, whether the stem is erect, spreading, prostrate, forms bunches, or continuous turf, etc.

Additional notes may be made, if possible, as to when the flower stalks appear, when the seed is ripe, when the seed is scattered, the period at which the range is usually grazed, and class of stock allotted to the range.

When thoroughly dry, the specimens may be placed in the final collection in the supervisor's office on white cardboard sheets fastened with narrow strips of strong, gummed paper. When filed, each specimen should be accompanied with a transcript of the collector's notes and the common and scientific names.

Identification of forage plants.

Unknown plants may be sent the Forester, who will arrange for their identification. All packages of specimens sent to the Forester should be marked plainly with the name and address of the sender. Correspondence relating to such specimens should be forwarded as usual, through the district forester.

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